The Unexpected Importance of Basic Scientific Research in Improving Public Health

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Nobel Laureate in Chemistry 1985

On the first day of the nineteenth century an Italian astronomer by the name of Piazzi discovered the asteroid Ceres, one of the thousands of little planets revolving around the sun between the orbits of Mars and Jupiter. Unbeknownst to the astronomer, the discovery would ultimately prove to be of great importance to human health.

Although Piazzi's discovery caused a great deal of excitement in astronomical circles, within five or six weeks he lost the little planet, in all likelihood because it went around the sun, or behind the sun, and so was no longer visible from earth. The time that it could be observed was of such a short interval that a precise orbit was not determined for this little planet. And so when Ceres returned to the neighborhood of the earth and could be observed, no one knew where to look for it.

In the meantime German mathematician Karl Friedrich Gauss, probably the greatest mathematician of all time, discovered a very important and far reaching principle, which came to be known as the principle of least squares. Gauss made the first application of his discovery in calculating a precise orbit for the asteroid which had disappeared, and when astronomers looked for this asteroid in the position that he predicted it would be, which was in October of the same year, indeed they found it there. And this was regarded in astronomical circles as little short of a miracle, such that Gauss became famous overnight and his principle of least squares came to be one of the most important tools in further scientific discoveries.

How could the discovery of this little planet, and the rediscovery of it by Gauss, be of such importance to our health today? The answer lies in the development of x-ray crystallography more than a century later in 1912. However, to reach that conclusion we must step back to look at how several other discoveries made during the nineteenth century contributed. One, on the face of which has no possible connection to human health, was the development of modern algebraic theories. A second, circa 1820, was the discovery of the concept of group theory by the young French mathematician Galois. It turned out that group theory was the basis of the essential method used for studying all kinds of symmetry, in particular symmetries of crystals. Crystals, as is commonly known, are very symmetrical objects, and the proper study of these crystals depended upon Galois' theory of groups.

Another essential development in the science of x-ray crystallography was the invention by the French mathematician Fourier of what has come to be known as modern harmonic analysis, or Fourier theory. And finally there was the research by a German physicist, P.O. Ewald who was writing his doctoral dissertation in the year 1912, the title of which was, "On the Propagation of Electro-Magnetic Radiation in a Medium Consisting of a Regular Arrangement of Resonators."
Again, one may wonder how any of this could have anything to do with the improvement of human health. And, again, the explanation is that the work was instrumental in the creation of the science of x-ray crystallography. Because when Ewald described his findings to the German physicist Max von Laue, von Laue had only one question: Were they valid for wavelengths of arbitrary size? Ewald's answer was yes, where upon Max von Laue suggested an experiment that would direct a beam of x-rays at a crystal. He predicted that the crystal would scatter the x-rays in different directions with different intensities, and that the nature of this so-called diffraction pattern would be uniquely determined by the structure of the crystal, which is to say the arrangement of the atoms in the crystal. The experiment was conducted and von Laue's prediction was dramatically confirmed.

The year 1912 therefore marked the beginning of the science of x-ray crystallography. The development of this science in the twentieth century must be considered one of the most remarkable developments in the whole history of science because, again, it provided a connection between the diffraction pattern and the structure of the crystals, or the arrangement of the atoms in the crystal. Methods based upon this experiment were developed and strengthened to the point that it has become possible, in fact even easy, to determine crystal structures and molecular structures routinely, even for very complex molecules consisting not merely of tens of atoms, or hundreds of atoms, but even for molecules consisting of thousands of atoms, which means that protein molecules can be clarified by means of this experiment.

Now the relationship to human health becomes clear. Because once it became possible to determine molecular structures of biologically important molecules routinely and easily, it became possible to relate molecular structures to life processes. In other words, one could understand how living things work at the molecular level, and what this meant, of course, is that one could finally design drugs routinely and with specified properties. We are now in a position of being able to design drugs that will do precisely what we want them to do with a minimum of adverse side effects. And so it became possible to improve the therapies for treating disease, and for preventing disease. Thus the improvement to human health – whether in reducing cholesterol levels or high blood pressure, or treating diabetes and other diseases – became more routine.

And all of this became possible only because of the preceding discoveries, from the discovery of the planet Ceres, to Gauss' discovery of least squares, to the discovery of x-ray diffraction and x-ray crystallography, all of which had been done with no thought of the possible usefulness in improving the public health. In short, none of these things would have become possible without the development of basic scientific research. And by that I don't necessarily mean basic biomedical science, but science in general. And so, I hope that I've made clear the importance of supporting basic scientific research. One can hardly ask for a greater benefit than the improvement of public health, and, therefore, of society in general.

Editor's Note:
Dr. Hauptman is the president of the Hauptman-Woodward Medical Research Institute in Buffalo, New York. Celebrating 50 years of exceptional scientific research, HWI is an independent, non-profit facility specializing in the area of fundamental biomedical research known as structural biology. Our team of more than 70 staff members is committed to improving human health by studying the causes of diseases, as well as potential therapies, at their basic molecular level. We are located in the heart of the Buffalo Niagara Medical Campus in downtown Buffalo, New York, in a new state-of-the-art structural biology research center at 700 Ellicott Street. For more information, visit HWI's website at www.hwi.buffalo.edu or call 716-898-8600.